Review on Continuously Variable Transmission

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Abstract*- Many other mechanical transmissions allows a few different gear ratio, but a continuously variable transmission can change through an infinite number of effective gear ratio from maximum to minimum value without sleeping. This allows the vehicle to run at its best revolution per minute (RPM) for different speed this gives a better fuel economy. the transmission of power from a rotating power source to a rotating load can be done by transmission. Conventional transmissions limits the engine to providing maximum power or efficiency for limited ranges of transmission output speed by allowing the selection of discrete gear ratios, this is achieved by Conventional variable Transmission system as it is possible to vary transmission ratio progressively. Selection of infinite number of ratios is possible by CVT. Thus the main function of CVT is to change transmission ratio continuously.[1]*

Keywords- CVT, Transmission, motor ,input shaft, output shaft

I. INTRODUCTION

A transmission system is a device which allows the transmission of power from a rotating power source to a rotating load. Conventional transmissions allow for the selection of discrete gear ratios, thus limiting the engine to providing maximum power or efficiency for limited ranges of transmission output speed.

The research was done by General Motors on CVTs in the year 1960,but no one saw their actual production. The use of CVT for several years in one of its smaller cars was dropped due to high cost, poor reliability and inadequate torque transmission by a British manufacturer Austin.[3]Audi then used the CVT successfully by overcoming all the drawbacks of the earlier system. Its CVT which they called multitronic was when installed in an A6 offered better fuel efficiency.[5].

Continuously variable transmission (CVT) is a system that makes it possible to vary progressively the transmission ratio. So it allows selection of an infinite number of ratios, (between a minimum and a maximum value). The purpose of CVT is thus to vary transmission ratio continuously. When engine runs at optimum speed the following benefits are offered;

a. Lower consumption of fuel.
b. Less greenhouse gas emissions
c. Better performance.

A continuously variable transmission (CVT) is a transmission which can change without steps through an infinite number of effective gear ratios between maximum and minimum values. This contrasts with other mechanical transmissions that only allow a few different discrete gear ratios to be selected. The flexibility of a CVT allows the driving shaft to maintain a constant angular velocity over a range of output velocities. This can provide better fuel economy than other transmissions by enabling the engine to run at its most efficient revolutions per minute (RPM) for a range of vehicle speed.

II. USES AND APPLICATIONS

1. Tractors just as cars have the need for a flexible system to convey power from their engine to their wheels. The CVT will provide just this and at high fuel savings with low atmospheric pollution.
2. Golf Carts stand to benefit from the CVT as well in the way electric cars do. That is: Large range of speeds, longer driving range between charges, fewer batteries, lower maintenance cost and less weight.
3. Ride on Lawn Mowers like small tractors are gas powered and contribute to the air pollution problem. The CVT approach can prevent ride-on to pollute the air to the extend they currently do.
4. 4.Motorized wheel chairs are powered electric batteries and speed is controlled by a rheostat. Going up a ramp slowly , causes a drop in power (when it's most needed). While CVT is a form of transmission in which lower speed means more power.

III. WORKING PRINCIPAL OF CVT

Fig 1 Assembly

The power is transmitted from a single phase AC motor, then transmitted to the smaller pulley, which is connected to the bigger pulley by a V-belt.

The input pulley is attached to the input shaft which holds the input cone, the input shaft rotates on two bearings which are welded to the bearing housing. The motion is transmitted from the input cone to the output cone through an element called shifter, which is movable link on the lead screw.

The position of the shifter can be changed to get the variation in speed and torque. The lead screw itself is attached on two bearings and rotates with rotation of shifter. The motion is ultimately transmitted to the output shaft from the shifter and input shaft.

IV. METHODOLOGY

A. DESIGN OF CONE CVT

Design consists of application of scientific principles, technical information and imagination for development of new or improvised machine or mechanism to perform a specific function with maximum economy and efficiency In our attempt to design a special purpose machine we have adopted a very careful approach and the total design work has been divided into two parts mainly;

- System design
- Mechanical design

System design mainly concerns with the various physical constraints and ergonomics, space requirements, arrangement of various components on the main frame of machine, number of controls and position of these controls, ease of maintenance scope of further improvement and height of machine from ground etc.

In Mechanical design the components are categorized in two parts.

- Design parts
- Parts to be purchased.

For design parts detail design is done and dimensions thus obtained are compared to next highest dimension which are readily available in market this simplifies the assembly as well as post production servicing work.

The various tolerances on work pieces are specified in the manufacturing drawings. The process charts are prepared and passed on to the manufacturing stage.The parts are to be purchased directly are specified and selected from standard catalogues.

B. MOTOR SELECTION

Thus selecting a motor of the following specifications

- Single phase AC motor
- Commutator motor
- TEFC construction
- Power = 120 watt
- Speed= 0-6000 rpm (variable)

Motor is a Single phase AC motor, power 120 watt, speed is continuously variable from 0 to 6000 rpm. The speed of motor is varied by means of an electronic speed variator. The motor is a commutator motor i.e., the current to motor is supplied to motor by means of carbon brushes. The power input to motor is varied by changing the electric supply to these brushes by the electronic speed variator, thereby the speed also changes. Motor is foot mounted and bolted to the motor base plate which is welded to the base frame of the indexer table.

INPUT DATA

- ELECTRIC MOTOR DETAILS
- POWER= 120 WATT
- SPEED = 0-6000 rpm
- OPERATING SPEED = 1000 rpm.

$$\text{Power (P)} = \frac{2 * \Pi * N * T}{60}$$

$$\Rightarrow 120 = \frac{2 * \Pi * 1000 * T}{60}$$

$$\Rightarrow T = \frac{60 * 120}{2 * \Pi * 1000}$$

$\Rightarrow T = 1.15$ N.m.

Considering 100% overload

$\Rightarrow T_{design} = 2\,T$

= 2.3N-m

C. DESIGN OF INPUT SHAFT

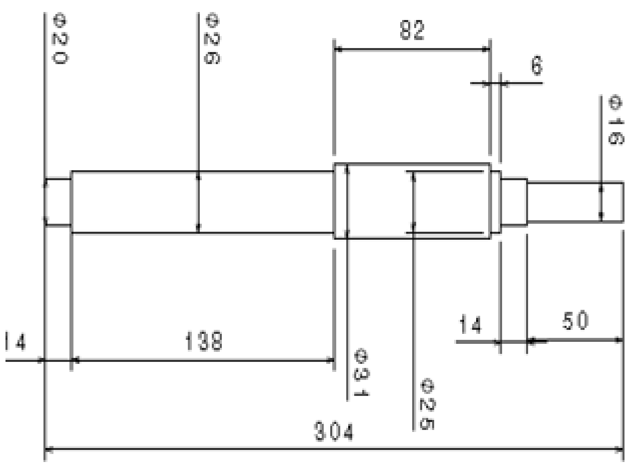

Fig. 2 Input Shaft

T_{Design} = 2.3 Nm.

= 2.3×10^3 N.mm

SELECTION 0F INPUT SHAFT MATERIAL

Table 1 Material Selection of input shaft [2]

Designation	Ultimate Tensile Strength N/mm^2	Yield strength N/mm^2
EN 24 (40 N; 2 Cr 1 Mo 28)	720	600

Using ASME code of design;

Allowable shear stress; Fs_{all} is given stress;

$Fs_{all} = 0.30 * S_{yt} = 0.30 \times 600$

=180 N/mm^2

$Fs_{all} = 0.18 * S_{ult} = 0.18 \times 720$

= 130 N/mm^2

Considering minimum of the above values;

Fs_{all} = 130 N/mm

As we are providing dimples for locking on shaft;

Reducing above value by 25%.

$\Rightarrow fs_{all} = 0.75 * 130$

= 97.5 N/mm^2

Considering pure torsional load;

$$T_{design} = \frac{\Pi * fs_{all} * d^3}{16}$$

$$d^3 = \frac{16 \times 2.3 \times 10^3}{\Pi * 97.5}$$

d = 4.7 mm

Selecting minimum diameter of spindle = 16 mm from ease of construction because the standard pulley has a pilot bore of 12.5 mm in as cast condition and a bore of minimum 16 mm for keyway slotting operation

D. DESIGN OF OUTPUT SHAFT

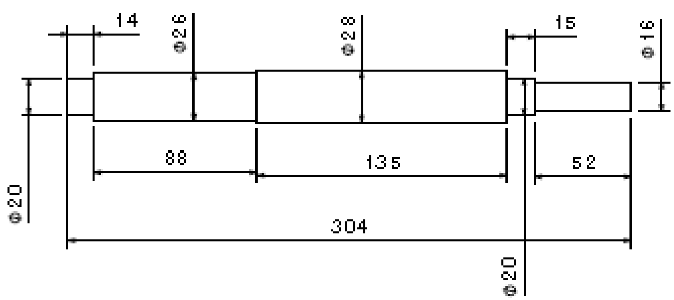

Fig .3 output shaft

T_{Design} = 2.3 N.m. = 2.3×10^3 N.mm

Selection of output shaft material

Table 2- Material Selection of output shaft [2]

Designation	Ultimate Tensile Strength N/mm^2	Yield strength N/mm^2
EN 24 (40 N; 2 cr 1 Mo 28)	720	600

Using ASME code of design;

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Reducing above value by 25%.

$Fs_{all} = 0.75 \times 130$

$= 97.5\ N/mm^2$

a) Considering pure torsional load;

$$T_{design} = \frac{\Pi * fs_{all} * d^3}{16}$$

$$d^3 = \frac{16 * 2.3 * 10^3}{\Pi * 97.5}$$

$d = 4.93$ mm

Selecting minimum diameter of output shaft

=9 mm.

E. SELECTION OF BEARING

Shaft bearing will be subjected to purely medium radial loads; hence we shall use ball bearings for our application. Selecting; Single Row deep groove ball bearing as follows.

Table no. 3 Bearing Selection [7]

IsI No	Bearing of basic design No	d	D1	D	D_2	B	Basic capacity	
17AC03	6204	20	19	43	33	14	2850	4650

$P = X\ F_r + Y\ F_a$

Where, Fr = Radial Load (kgf)

X = Radial Load Factor

Y= Axial Load Factor

Fa= Axial Load (kgf)

For our application $F_a = 0$

$\Rightarrow P = X\ F_r$

As; $F_r < e \Rightarrow X = 1$

$\Rightarrow P = F_r$

Max radial load = $F_r = 192$ N

$\Rightarrow P = 192N$

Calculation dynamic load capacity of bearing

$L = \left(\frac{C}{P}\right)^p$, where p= 3 for ball bearings

Where, C = dynamic load capacity of bearing

L = Basic rating life (10^6)

P = Bearing load (equivalent load)

When P for ball bearing

Assuming;

$L_H = 4000- 8000hr$

But; $L = \frac{60\ n\ L_H}{10^6}$

L=48 millions of revolution

Now; $48 = \frac{(C)^3}{192}$

C= 698 N.

As the required dynamic capacity of bearing is less than the rated dynamic capacity of bearing.

V. TESTING

CALCULATION OF INPUT SPEED

We have,

Motor speed Nem=1000rpm,

Diameter of motor pulley Dem= 50 mm

Diameter of Drive pulley Di=144mm

Formula, Nem / Ni = Di / Dem

Hence,

Input shaft speed is Ni=348rpm

CALCULATION OF MINIMUM SPEED

For Minimum speed

Ni/Nmin = Dmin/Di

348/Ni=42/100

Nmin =147rpm

CALCULATION OF MAXIMUM SPEED

For Maximum Speed
348/Ni=100/42
Nmax=828rpm

VI. CONCLUSION

The CVT offers a reasonable alternative for any application requiring continuous speed variation. It is relatively simple design and provides easy stable ratio control.CVT is an automatic transmission that can relate any desired drive ratio within its operating range.

It gives constant step less acceleration from start to high speed by eliminating ‘shift shock’ to provide a smoother ride.

CVT keeps the car in optimum power range under all conditions thus decreasing fuel consumption. Its response is better to changing conditions like throttle and speed changes, which eliminates gear hunting while moving up an incline. CVT has better control of engine under all operating conditions leading to less emissions.

By increasing the number of linkages we will be able to increase the motion of transmission.

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